Effect of Prescribed Fire and Mechanical Fuel Treatments on Soil Carbon Respiration in Pine Flatwoods

David R. Godwin and Leda N. Kobziar

School of Forest Resources and Conservation, College of Agricultural and Life Sciences, University of Florida, Gainesville, Florida, USA

UF UNIVERSITY of FLORIDA
College of Agricultural and Life Sciences

Introduction

The understanding of soil carbon dynamics in forested systems has increased in importance as global climate change discussions recognize the key role forest soils play in global carbon cycles. The majority of carbon sequestered in most forested systems lies within the soils, with soil carbon respiration comprising a significant portion of total ecosystem carbon budgets.

One method for assessing how management affects forest carbon dynamics is the measurement of soil carbon respiration rates. A variety of forest management activities, including prescribed fire, have been shown to significantly influence soil carbon respiration rates in the Western United States, yet these relationships are not well known in southern forests. Prescribed fire is one of the most prevalent forest management tools employed in the Southeastern US, and mechanical fuels mastication treatments are becoming more common in the region as concerns over wildfire risk and smoke in the wildland urban interface grow.

This study seeks to understand the influence of prescribed fire and mechanical understory fuel reduction treatments (mowing) on soil carbon respiration rates in the flatwoods forest of the Osceola National Forest, representing the most common natural forest type in Florida. The primary goal of this study is to understand the impact of management type on forest soil temperature, soil moisture content, and soil carbon respiration rates.

Study Area

The study site is located within the Osceola National Forest in Columbia County, FL, USA approximately 20 km from the town of Lake City (30° 14'N, -082° 31'W). Vegetation across all sites consists of an overstory mixture of naturally regenerated slash pine (*Pinus elliottii*) and longleaf pine (*Pinus palustris*) and an understory composed of saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), and deerberry (*Vaccinium stamineum*) shrubs.

LICOR Biosciences LI-8100 automated soil CO_2 flux measurement system with attached 20 cm survey chamber and auxiliary sensor input unit deployed in a recently burned flatwoods site.

Methods

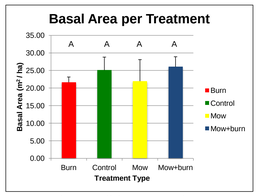
The study consisted of twelve plots in a 4 x 3 study design representing four management regime combinations: burn only, mow only, mow+burn, and an unburned-unmowed control (unburned for ~ 10 yrs). Three replicate sampling plots were randomly established within stands representing each treatment type or control. Each R_s sampling plot consisted of nine permanently installed 20 cm diameter PVC collars hammered into the ground, arranged in a 3 x 3 grid with 5 m separation. R_s measurements were conducted monthly over the course of two days on an approximately four-week rotation. To account for diurnal variations in R_s, measurements were taken in each plot once in the morning and once in the afternoon. Measurements were conducted using a LI-COR Biosciences LI-8100 automated soil CO_2 flux system with a 20 cm survey chamber that sealed over each PVC collar. Concurrently with R_s measurements, soil temperature (T_s), and soil moisture (M_s), were recorded within 20 cm of each collar at a depth of 10 cm using an auxiliary sensor input and data logger onboard the LI-8100.

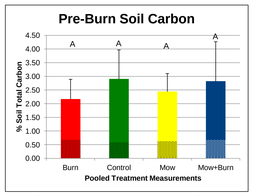
Unburned Control Treatment

Mow Only Treatment

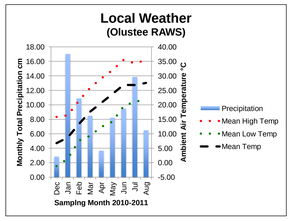
Burn Only Treatment

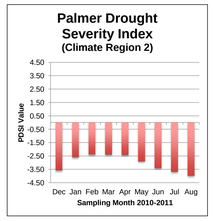
Mow+Burn Treatment





Basal area did not vary by treatment type. This was consistent with the management goals of the mowing and prescribed fire treatments. Pre-burn soil carbon assessments showed no significant differences between treatment types. A post-burn soil carbon assessment will occur this winter.

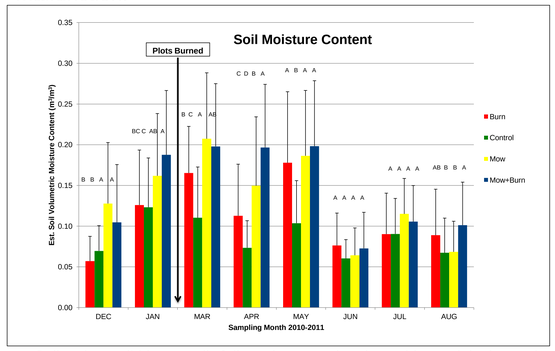




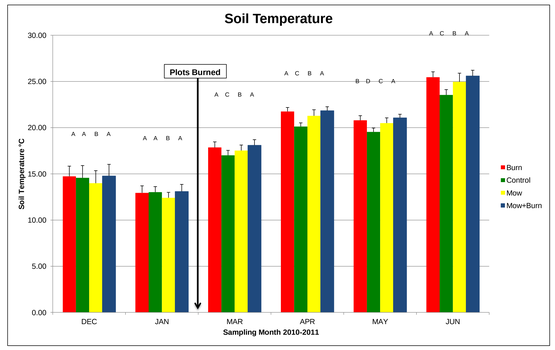
Air temperature increased seasonally throughout the study period, with precipitation via rainfall highly variable. The region experienced a building and severe drought during the period of study as indicated by the regional PDSI values.

Results

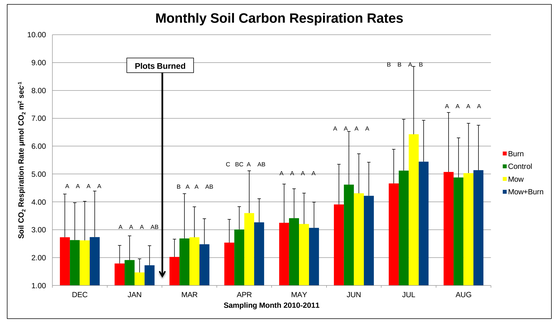
Sampling plots were established in November of 2010 following mowing treatments in the summer of 2010. Plots were sampled monthly from December 2010 through August 2011. Burning was conducted in February of 2011, during which R_s/T_s/M_s measurements were not taken. Soil temperature measurements were not recorded in July and August due to an equipment malfunction.



Soil moisture (M_s) generally followed seasonal and monthly precipitation and drought trends with treatment effects apparently diminished during the summer months. Burning increased M_s while mowing increased M_s more so. Burning in the mowed sites did not have a clear effect relative to mow only treatment.



Soil temperature (T_s) increased throughout the study period in all treatments. Mowing decreased T_s in the winter months and increased T_s during the spring and summer months. Burning increased soil temperature in both the burn and mow+burn treatments.



Monthly soil carbon respiration rates (R_s) varied seasonally with rates increasing January through July. Burning reduced R_s rates in the burn and mow+burn treatments while mowing alone showed no clear effect on R_s rates. R_s rates were positively linearly correlated with T_s (~R^2 = 30 for all treatments) but showed little correlation with M_s variability.

Conclusions

- Burning alone reduced R_s in what appears to be a trend diminishing since treatment, while mowing had no clear effect on R_s.
- Burning increased T_s in the spring and summer months. Mowing decreased T_s in the winter and increased soil temperature in the spring and summer.
- Burning and mulching both increased M_s, however a combination of burning and mulching resulted in no clear effect.
- T_s explained some of the variability of R_s which is consistent with previous studies of R_s in other systems.

It appears that the effect of prescribed fire and mowing on R_s is short-lived (fire) or nonexistent (mowing) in this system. However prolonged changes in soil microenvironmental conditions (e.g. temperature and moisture) due to fuel treatments may have long-term implications for soil carbon dynamics, as soil temperature and moisture have been shown to regulate heterotrophic microorganism metabolism. Increased activity of such organisms due to elevated temperature and moisture may lead to accelerated soil carbon respiration rates and soil carbon loss.

Acknowledgments

Funding for this project came from a 2010 Graduate Innovation (GRIN) grant from the Joint Fire Science Program and the Association for Fire Ecology. The study would not have been possible without the support and cooperation of the United States Forest Service Osceola National Forest. Special thanks to the leadership of PhD Candidate Jesse Kreye for help in establishing the treatments. Field data were collected with the tireless assistance of a great team of technicians: Mike Camp, Marissa Streifel, and Alex Kattan.

Contact Information

David R. Godwin - PhD Candidate
Fire Science Lab
School of Forest Resources & Conservation
University of Florida

Email: drg2814@ufl.edu
Twitter: @ThatFireSciGuy
Web: www.sfrc.ufl.edu/fire

Joint Fire Science Program

FOREST SERVICE US DEPARTMENT OF AGRICULTURE